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**Proposal Number:** 06-NL-320  
**Research Title:** (DURIP-07) OPTIMIZING PERFORMANCE THROUGH SLEEP-WAKE HOMEOSTASIS: INTEGRATING PHYSIOLOGICAL AND NEUROBEHAVIORAL DATA VIA AMBULATORY ACQUISITION IN LABORATORY AND FIELD ENVIRONMENTS  
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**Primary Investigator:** Dr. David F. Dinges  
**Invention Ind:** none  
**Project/Task:** 5094U / S  
**Program Manager:** Willard D. Larkin

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The objective of our current AFOSR research (FA9550-05-1-0293) is to evaluate whether cognitive task difficulty from increased performance demands on attention will interact with acute total sleep loss and manifest in EEG slow wave energy and absolute cerebral blood flow (fMRI) measures of sleep-wake homeostasis. The instrumentation for which we received DURIP funding has three major components, each of which markedly enhances the quality of research and research-related education via our AFOSR project. The three components are: (1) Compumedics USA Siesta 802 Wireless & Ambulatory Recording System for ambulatory physiological acquisition and quantitative signal processing; (2) BrainAmp MR Plus 32 and Brain Vision Recorder Professional Software Package for the simultaneous acquisition of EEG and MRI data during functional neuroimaging; and (3) Dell servers with Dual Core Xeon processor for expanded data storage and access, as a result of data-in-flow from the first two components.

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## **FINAL PERFORMANCE REPORT**

**TITLE: Optimizing performance through sleep-wake homeostasis: Integrating physiological and neurobehavioral data via ambulatory acquisition in laboratory and field environments.**

**AWARD NO.:** FA9550-07-1-0309  
**PRINCIPAL INVESTIGATOR:** David F. Dinges, Ph.D.  
**PROJECT PERIOD:** 1 April 2007 to 31 March 2008

## **Section 1: Accomplishment of Goals and Objectives**

### **SUMMARY OF FULFILLED OBJECTIVES**

The objective of our current AFOSR research (FA9550-05-1-0293) is to evaluate whether cognitive task difficulty from increased performance demands on attention will interact with acute total sleep loss and manifest in EEG slow wave energy and absolute cerebral blood flow (fMRI) measures of sleep-wake homeostasis. The instrumentation for which we received DURIP funding has three major components, each of which markedly enhances the quality of research and research-related education via our AFOSR project. The three components are: (1) Compumedics USA Siesta 802 Wireless & Ambulatory Recording System for ambulatory physiological acquisition and quantitative signal processing; (2) BrainAmp MR Plus 32 and BrainVision Recorder Professional Software Package for the simultaneous acquisition of EEG and MRI data during functional neuroimaging; and (3) Dell Servers with Dual Core Xeon processor for expanded data storage and access, as a result of data in-flow from the first two components. Together these three components form a dynamic, flexible data acquisition and archiving system that permit expanded intake and sophisticated signal processing of electroencephalographic (EEG), electrooculographic (EOG), electrocardiographic (ECG), and electromyographic (EMG) physiological signals; real-time acquisition and analyses of EEG and fMRI data in the laboratory; and expansion of electronic data archive with simultaneous acceleration of data processing. Thus the acquired instrumentation enhances both the science conducted under FA9550-05-1-0293, and the scientific insights from our related Federally-funded studies of cognitive recovery from sleep loss. The equipment also amplifies and accelerates our didactic efforts to provide trainees access to technologically advanced research tools relevant to the biological basis of behavior, thereby increasing the quality of training in



scientific areas relevant to DoD and AFOSR goals. Overall, the research supported by this DURIP award is scientifically and technologically cutting edge, with a high likelihood of leading to consequential new discoveries relevant to both the advancement of basic science and Air Force needs.

The acquired instrumentation has three major components—each of which markedly enhances the quality of research and research-related education via AFOSR FA9550-05-1-0293. These three components are: (1) Compumedics USA Siesta 802 Wireless & Ambulatory Recording System for ambulatory physiological acquisition and quantitative signal processing; (2) BrainAmp MR Plus 32 and BrainVision Recorder Professional Software Package for the simultaneous acquisition of EEG and MRI data during functional neuroimaging; and (3) Dell Servers with Dual Core Xeon processor for expanded data storage and access, as a result of data in-flow from the first two components.

Together these three components form a dynamic, flexible data acquisition and archiving system that make possible our current AFOSR research on the interaction of cognitive task difficulty (from increased attentional demands) with acute total sleep loss, and the expression of this interaction in quantitative measures of sleep-wake homeostasis—especially EEG slow wave energy and absolute cerebral blood flow (using fMRI). Thus, the acquired instrumentation markedly enhances the first systematic scientific evaluation of the effects of increasing cognitive task difficulty on sleep-wake homeostasis, as well as increasing the scientific insights from our related Federally-funded studies of cognitive recovery from sleep loss. The equipment also amplifies and accelerates our didactic efforts to provide trainees access to technologically advanced research tools relevant to the biological basis of behavior, thereby accelerating their training in scientific areas relevant to DoD and AFOSR goals. The precise ways in which the equipment impacts the quality of our current AFOSR research and research-related education is detailed in the Supporting Information below.

#### SUPPORTING INFORMATION

The scientific equipment acquired through DURIP enhances the quality of research and research-related education, establishes new research capabilities and enhances current research capabilities for a project currently funded by the DoD Air Force Office of Scientific Research (AFOSR), entitled “Effects of Cognitive Task Difficulty on Sleep-Wake Homeostasis”, Grant number FA9550-05-1-0293, Principal Investigator, David F. Dinges, Ph.D. This project is funded through the AFOSR Directorate of Chemistry and Life Sciences and involves biological and behavioral research focused on ways to increase performance and operational flexibility through a better understanding of sleep-wake chronobiology.

The acquired instrumentation has three major components—each of which markedly enhances the quality of research and research-related education currently funded via AFOSR FA9550-05-1-0293. These three components are: (1) Compumedics USA Siesta 802 Wireless & Ambulatory Recording System for ambulatory physiological acquisition and quantitative signal processing; (2) BrainAmp MR Plus 32 and BrainVision Recorder Professional Software Package for the simultaneous acquisition of EEG and MRI data during functional neuroimaging; and (3) Dell Servers with Dual Core Xeon processor for expanded data storage and access.

**Component 1.** *Compumedics USA Siesta 802 Wireless & Ambulatory Recording System* for ambulatory physiological acquisition and quantitative signal processing

This new system provides faster acquisition, analyses and archiving neurobehavioral and electrophysiological data relevant to our studies of sleep-wake homeostasis. The new system is vastly more flexible than our aging current system for physiological data acquisition (which is expensive to maintain), and it has software that will permit accelerated acquisition and sophisticated signal processing of electroencephalographic (EEG), electrooculographic (EOG), electrocardiographic (ECG), and electromyographic (EMG) physiological signals. It also has markedly superior capacity for information resources and increased data archiving capabilities that will enhance our current research for AFOSR on sleep homeostasis, as well as our related Federally-funded research on sleep loss and cognitive performance.

**Component 2.** *BrainAmp MR Plus 32 and BrainVision Recorder Professional Software Package* for the simultaneous acquisition of EEG and MRI data during functional neuroimaging.

The second component of the acquired instrumentation system is the BrainAmp MR Plus 32 and BrainVision Recorder Professional Software Package. This equipment is unique in the world in that it permits simultaneous acquisition of human EEG (and EOG, EMG) data while subjects are undergoing functional magnetic resonance imaging (fMRI). It offers a unique opportunity to acquire EEG data and MRI images of brain activation areas in rested and sleep-deprived subjects undertaking cognitive tasks.

**Component 3.** *Dell Servers with Dual Core Xeon Processor* for data storage and analyses

A new comprehensive ambulatory physiological data acquisition system (component 1) for laboratory experiments for AFOSR, and a system for simultaneous recording of EEG and fMRI data (component 2) for monitoring brain activation in relationship to differential vulnerability to the cognitive effects of sleep loss in our AFOSR studies, have resulted in a much larger database and consequently, require a substantially larger data archive system (component 3) for multiple users to access and analyze data. Much of our research related education relies on students being able to access the data and learn analysis techniques. Consequently the third aspect of the acquired instrumentation is a new high-capacity, high-speed server for data archive and data analyses.

## **Section 2: (N/A) - Unfulfilled Goals and Objectives**

All goals and objectives, as stated in the original proposal, have been fulfilled.

## **Section 3: Other Information**

There were no cost overruns for this project. We were able to acquire all necessary equipment with the funds awarded.